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catena-Poly[[triphenyltin(IV)]-μ-phenylphosphinato-κ^2O:O']

Tidiane Diop, Libasse Diop, Gabriele Kociok-Köhn, Kieran C. Molloy and Helen Stoeckli-Evans

Acta Cryst. (2011). E**67**, m1674–m1675

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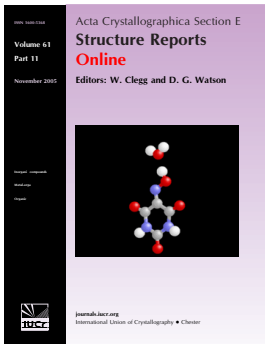

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catena-Poly[[triphenyltin(IV)]-μ-phenylphosphinato-κ^2O:O']

Tidiane Diop,[a] Libasse Diop,[a]* Gabriele Kociok-Köhn,[b] Kieran C. Molloy[b] and Helen Stoeckli-Evans[c]*

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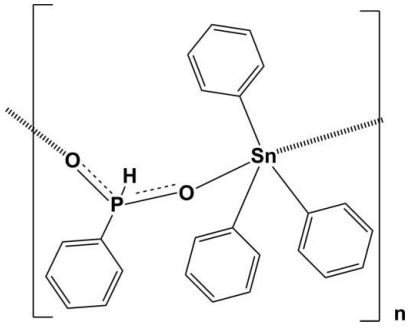
Key indicators: single-crystal X-ray study; T = 173 K; mean σ(C–C) = 0.009 Å; R factor = 0.052; wR factor = 0.079; data-to-parameter ratio = 14.9.

In the structure of the title coordination polymer, $[Sn(C_6H_5)_3(C_6H_6O_2P)]_n$ or $[PhP(H)O_2Sn^{IV}(Ph)_3]_n$, the Sn^{IV} atom is five-coordinate, with the SnC_3O_2 framework in a *trans* trigonal–bipyramidal arrangement having the $PhP(H)O_2^-$ anions in apical positions. In the crystal, neighbouring polymer chains are linked *via* C—H$\cdots\pi$ interactions, forming a two-dimensional network lying parallel to (001).

Related literature

For medical applications of tin(IV) compounds, see: Evans & Karpel (1985); Kapoor *et al.* (2005); Yin & Wang (2004). For literature on new organotin compounds, see: Chandrasekhar *et al.* (2003); Davies & Smith (1982); Zhang *et al.* (2006). For work in this field carried out by the authors, see: Diassé-Sarr *et al.* (1997); Diop *et al.* (2002, 2003); Diallo *et al.* (2009). For related structures, see: Molloy *et al.* (1981); Adair *et al.* (2003).



Experimental

Crystal data

$[Sn(C_6H_5)_3(C_6H_6O_2P)]$
M_r = 491.07
Orthorhombic, *Pbca*
a = 14.0108 (6) Å
b = 11.7674 (7) Å
c = 25.7068 (12) Å
V = 4238.3 (4) Å^3
Z = 8
Mo $K\alpha$ radiation
μ = 1.30 mm^{-1}
T = 173 K
0.18 × 0.13 × 0.10 mm

Data collection

Stoe IPDS II diffractometer
Absorption correction: multi-scan (*MULscanABS* in *PLATON*; Spek, 2009)
T_{min} = 0.973, T_{max} = 1.000
27270 measured reflections
3829 independent reflections
2467 reflections with $I > 2\sigma(I)$
R_{int} = 0.117

Refinement

$R[F^2 > 2\sigma(F^2)]$ = 0.052
$wR(F^2)$ = 0.079
S = 1.00
3829 reflections
257 parameters
H atoms treated by a mixture of independent and constrained refinement
$\Delta\rho_{max}$ = 0.47 e Å^{-3}
$\Delta\rho_{min}$ = −0.68 e Å^{-3}

Table 1
Hydrogen-bond geometry (Å, °).

*Cg*1 is the centroid of the C19–C24 ring.

D—H$\cdots A$	D—H	H$\cdots A$	$D\cdots A$	D—H$\cdots A$
C9—H9$\cdots$*Cg*1^{i}	0.95	2.79	3.656 (9)	151
C18—H18$\cdots$*Cg*1^{ii}	0.95	2.91	3.714 (6)	143

Symmetry codes: (i) $x+\frac{1}{2}, y, -z+\frac{1}{2}$; (ii) $-x-\frac{1}{2}, y+\frac{1}{2}, z$.

Data collection: *X-AREA* (Stoe & Cie, 2009); cell refinement: *X-AREA*; data reduction: *X-RED32* (Stoe & Cie, 2009); program(s) used to solve structure: *SHELXS97* (Sheldrick, 2008); program(s) used to refine structure: *SHELXL97* (Sheldrick, 2008); molecular graphics: *PLATON* (Spek, 2009) and *Mercury* (Macrae *et al.*, 2008); software used to prepare material for publication: *SHELXL97*, *PLATON* and *publCIF* (Westrip, 2010).

HSE thanks the staff of the X-ray Diffraction Application Laboratory, CSEM, Neuchâtel, for access to the X-ray diffraction equipment.

Supplementary data and figures for this paper are available from the IUCr electronic archives (Reference: MW2028).

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catena-Poly[[triphenyltin(IV)]-μ-phenylphosphinato-$\kappa^2O:O'$]I

T. Diop, L. Diop, G. Kociok-Köhn, K. C. Molloy and H. Stoeckli-EvansI

Comment

As some compounds belonging to the organotin (IV) family have been found to be the subject of applications in medicine,i agriculture, industry (Evans & Karpel, 1985; Kapoor *et al.*, 2005; Yin & Wang, 2004), many groups have been involved ini the search for new organotin compounds (Davies & Smith, 1982; Zhang *et al.*, 2006; Chandrasekhar *et al.*, 2003). Our groupi has published a number of papers in this field (Diassé-Sarr *et al.*, 1997; Diop *et al.*, 2003; Diop *et al.*, 2002; Diallo *et al.*,i 2009). In a continuation of this work we initiated the study of the interaction between $Cy_2NH_2PhP(H)O_2$ and $Sn(Ph)_3Cl$,i which has led to the synthesis of the title coordination polymer.i

The structure of the asymmetric unit of the title compound is illustrated in Fig. 1. The molecular units associate to formi an infinite one-dimensional polymer (Fig. 2) in which trimethyltin(IV) groups are axially bridged by –O—P—O– linkagesi of the phenylphosphinate ligand to yield an almost perfect trigonal bipyramid at the tin(IV) atom; with equatorial locationi of the phenyl groups and axial disposition of the oxygenated ligand.i

The sum of the angles at atom Sn1 by the *ipso*-carbons [124.1 (2), 119.4 (3), 116.4 (3) °] is 359.9°. The correspondingi axial O1—Sn—O2 angle is 175.99 (15) °, indicating a slight deviation from linearity. The two axial Sn—O distances,i [Sn1—O1 2.241 (4) Å and Sn—O2 2.237 (3) Å], are longer than the Sn—O axial distances [2.116 (2) Å and 2.132 (3) Å]i observed in *catena*-(μ_2-phenylphosphinato-O,*O*')-choro-tin(II) [Adair *et al.*, 2003]. The two P—O distances of the bridgingi O1—P1—O2 moieties are also almost equal [P1—O1 1.514 (4) Å and P1—O2 1.501 (4) Å]. The geometry around thei phosphorus atom is a distorted tetrahedron with bond angles ranging from 114.4 (2)° for O1—P1—O2 to 103 (2)° fori C1—P1—H1. The P1—H1 distance is 1.33 (5) Å, similar to the same distance, of 1.39 (7) Å, observed in the compoundi mentioned above.i

In the crystal, neighbouring chains are linked *via* C—H···π interactions, involving the phenyl ring (C19—C24). Thisi results in the formation of a two-dimensional network structure lying parallel to the *ab*-plane (Table 1 and Fig. 3).i

Footnote to Table 1: *Cg*1 is the centroid of ring (C19—C24).i

Experimental

Synthesis: $Cy_2NH_2Ph(H)PO_2$ (*L*) was obtained on neutralizing phenylphosphinic acid with dicyclohexylammine, in 1:2i ratio, in water; a white powder was collected after evaporation at 333 K. When (*L*) was mixed with $Sn(Ph)_3Cl$ (1:1 ratio,i *M*.p. +533 K), both in ethanol, a white precipitate formed and the solution was stirred for a further 2 h. The mixture wasi then filtered and the solid dissolved in 25 ml of slightly hydrated methanol. The solution was then left for the solventi to slowly evaporate giving colourless crystals, suitable for X-ray diffraction analysis, of the title compound. Reaction:i $Cy_2NH_2Ph(H)PO_2 + Sn(Ph)_3Cl \rightarrow PhP(H)O_2Sn(Ph)_3 + Cy_2NH_2Cl$. The same compound could be obtained by refluxingi trimethyltin chloride with phenylphosphinic acid in water: $Ph(H)PO_2H + Sn(Ph)_3Cl \rightarrow PhP(H)O_2Sn(Ph)_3 + HCl$.i

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Refinement

The PH H-atom was located in a difference Fourier map and was refined with U_{iso}(H) = 1.2U_{eq}(P); [P—H = 1.33 (5) Å].i The C-bound H atoms were included in calculated positions and treated as riding atoms: C—H = 0.95 Å with U_{iso}(H) =i 1.2U_{eq}(C).i

Figures

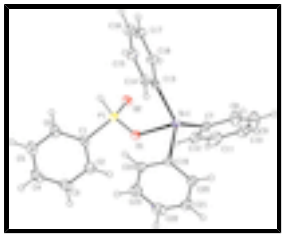

Fig. 1. A view of the asymmetric unit of the title compound, showing the numbering schemei and displacement ellipsoids drawn at the 50% probability level.i

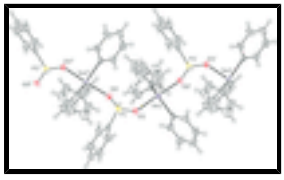

Fig. 2. A view normal to (001) of the polymer chain of the title compound [Symmetry codes:i (i) -*x* - 1/2, *y* - 1/2, *z*; (i) -*x* - 1/2, *y* + 1/2, *z*; displacement ellipsoids are drawn at the 50%i probability level].i

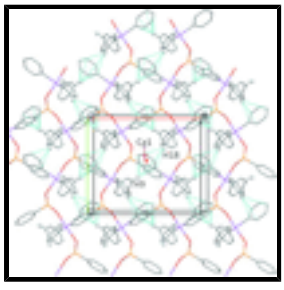

Fig. 3. A view along the *c* axis of the crystal packing of the title compound showing the weaki C—H···π interactions [represented by the H···C dashed cyan lines; Sn violet; P yellow; O red;i H grey ball; *Cg*1 = centroid of ring (C19—C24)].i

catena-Poly[[triphenyltin(IV)]-μ-phenylphosphinato-κ^2*O*:*O*']

Crystal datar

$[Sn(C_6H_5)_3(C_6H_6O_2P)]$i	F(000) = 1968.
M_r = 491.07i	D_x = 1.539 Mg m^{-3}i
Orthorhombic, *Pbca*	Mo *K*α radiation, λ = 0.71073 Åi
Hall symbol: -P 2ac 2abi	Cell parameters from 10452 reflectionsi
a = 14.0108 (6) Åi	θ = 1.6–26.1°i
b = 11.7674 (7) Åi	μ = 1.30 mm^{-1}i
c = 25.7068 (12) Åi	*T* = 173 Ki
V = 4238.3 (4) Å^{3}i	Rod, colourlessi
Z = 8i	0.18 × 0.13 × 0.10 mmi

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Data collection

Stoe IPDS IIi diffractometeri	3829 independent reflections
Radiation source: fine-focus sealed tubei	2467 reflections with $I > 2\sigma(I)$i
plane graphitei	$R_{int} = 0.117$i
φ and ω scansi	$\theta_{max} = 25.3°$, $\theta_{min} = 1.6°$i
Absorption correction: multi-scani (MULscanABS in *PLATON*; Spek, 2009)	$h = -16\rightarrow16$i
$T_{min} = 0.973$, $T_{max} = 1.000$i	$k = -14\rightarrow14$i
27270 measured reflectionsi	$l = -28\rightarrow30$i

Refinement

Refinement on F^2i	Secondary atom site location: difference Fourier mapi
Least-squares matrix: fulli	Hydrogen site location: inferred from neighbouringi sitesi
$R[F^2 > 2\sigma(F^2)] = 0.052$i	H atoms treated by a mixture of independent and constrained refinementi
$wR(F^2) = 0.079$	$w = 1/[\sigma^2(F_o^2) + (0.0275i)^2]$i where i $= (F_o^2 + 2F_c^2)/3$i
$S = 1.00$i	$(\Delta/\sigma)_{max} = 0.001$i
3829 reflectionsi	$\Delta\rho_{max} = 0.47$ e Å^{-3}i
257 parametersi	$\Delta\rho_{min} = -0.68$ e Å^{-3}i
0 restraintsi	Extinction correction: *SHELXL97* (Sheldrick, 2008), $Fc^* = kFc[1+0.001xFc^2\lambda^3/\sin(2\theta)]^{-1/4}$i
Primary atom site location: structure-invariant directi methodsi	Extinction coefficient: 0.00036 (5)i

Special details

Geometry. Bond distances, angles *etc*. have been calculated using the rounded fractional coordinates. All su's are estimated from thei variances of the (full) variance-covariance matrix. The cell e.s.d.'s are taken into account in the estimation of distances, angles and tor-i sion anglesi

Refinement. The PH H-atom was located in a difference Fourier map and was refined with U_{iso}(H) = 1.2U$_e$q(P). The C-bound H-i atoms were included in calculated positions and treated as riding atoms: C—H = 0.95 Å for CH(aromatic), with U_{iso}(H) = 1.2U$_e$q(C).i

Fractional atomic coordinates and isotropic or equivalent isotropic displacement parameters (Å^2)

	x	*y*	*z*	U_{iso}*/U_{eqi}
Sn1i	−0.29327 (3)i	−0.35558 (3)i	0.36284 (1)i	0.0260 (1)i
P1i	−0.36921 (12)i	−0.08232 (12)i	0.38935 (6)i	0.0286 (5)i
O1i	−0.3855 (3)i	−0.2003 (3)i	0.36764 (17)i	0.0295 (11)i
O2i	−0.2923 (3)i	−0.0161 (2)i	0.36231 (17)i	0.0350 (11)i
C1i	−0.4806 (4)i	−0.0060 (4)i	0.3878 (3)i	0.029 (2)i
C2i	−0.5372 (5)i	−0.0034 (5)i	0.3438 (3)i	0.047 (3)i
C3i	−0.6217 (5)i	0.0586 (6)i	0.3440 (3)i	0.053 (3)i

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C4i	−0.6498 (5)i	0.1153 (5)i	0.3884 (3)i	0.052 (3)i
C5i	−0.5930 (5)i	0.1151 (5)i	0.4317 (3)i	0.050 (3)i
C6i	−0.5077 (5)i	0.0548 (5)i	0.4313 (3)i	0.040 (2)i
C7i	−0.2349 (4)i	−0.3088 (5)i	0.2893 (2)i	0.0317 (19)
C8i	−0.1608 (5)i	−0.3689 (6)i	0.2669 (3)i	0.050 (3)i
C9	−0.1227 (6)i	−0.3364 (7)i	0.2197 (3)i	0.065 (3)i
C10i	−0.1576 (6)i	−0.2451 (6)i	0.1937 (3)i	0.054 (3)i
C11i	−0.2315 (6)i	−0.1838 (6)i	0.2150 (3)i	0.059 (3)i
C12i	−0.2705 (5)i	−0.2148 (5)i	0.2623 (2)i	0.041 (2)i
C13i	−0.2300 (4)i	−0.3139 (4)i	0.4356 (2)i	0.0260 (18)i
C14i	−0.2518 (5)i	−0.3764 (4)i	0.4803 (2)i	0.0323 (17)i
C15i	−0.2086 (5)i	−0.3528 (5)i	0.5273 (2)i	0.0400 (17)i
C16i	−0.1414 (5)i	−0.2654 (5)i	0.5310 (3)i	0.042 (3)i
C17i	−0.1206 (5)i	−0.2024 (5)i	0.4872 (2)i	0.039 (2)i
C18i	−0.1629 (4)i	−0.2252 (5)i	0.4404 (2)i	0.0327 (19)
C19	−0.4177 (4)i	−0.4597 (4)i	0.3655 (3)i	0.0273 (16)i
C20i	−0.4303 (5)i	−0.5480 (5)i	0.3302 (3)i	0.038 (2)i
C21i	−0.5101 (5)i	−0.6171 (5)i	0.3344 (3)i	0.047 (3)i
C22i	−0.5766 (5)i	−0.5986 (5)i	0.3719 (3)i	0.050 (3)i
C23i	−0.5660 (5)i	−0.5107 (6)i	0.4068 (3)i	0.048 (3)i
C24i	−0.4866 (4)i	−0.4413 (5)i	0.4031 (2)i	0.034 (2)i
H1i	−0.351 (4)i	−0.089 (4)i	0.440 (2)i	0.0340*i
H2i	−0.51850i	−0.04380i	0.31350i	0.0570*i
H3i	−0.66010i	0.06180i	0.31360i	0.0640*i
H4i	−0.70900i	0.15470i	0.38890i	0.0620*i
H5i	−0.61170i	0.15600i	0.46190i	0.0590*i
H6i	−0.46790i	0.05530i	0.46120i	0.0480*i
H8i	−0.13570i	−0.43360i	0.28430i	0.0600*i
H9	−0.07140i	−0.37860i	0.20510i	0.0770*i
H10i	−0.13120i	−0.22350i	0.16120i	0.0650*i
H11i	−0.25600i	−0.11970i	0.19700i	0.0710*i
H12i	−0.32180i	−0.17200i	0.27650i	0.0500*i
H14i	−0.29720i	−0.43620i	0.47820i	0.0390*i
H15i	−0.22460i	−0.39600i	0.55730i	0.0480*i
H16i	−0.11060i	−0.24970i	0.56310i	0.0510*i
H17i	−0.07590i	−0.14200i	0.48960i	0.0460*i
H18i	−0.14700i	−0.18070i	0.41070i	0.0390*i
H20i	−0.38480i	−0.56080i	0.30350i	0.0450*i
H21i	−0.51820i	−0.67840i	0.31080i	0.0570*i
H22i	−0.63100i	−0.64670i	0.37400i	0.0600*i
H23i	−0.61240i	−0.49800i	0.43310i	0.0570*i
H24i	−0.47930i	−0.37990i	0.42670i	0.0410*i

Atomic displacement parameters (Å^2)

	U^{11i}	U^{22i}	U^{33i}	U^{12i}	U^{13i}	U^{23i}
Sn1i	0.0255 (2)i	0.0192 (2)i	0.0334 (2)i	−0.0004 (2)i	0.0006 (2)i	0.0008 (2)i
P1i	0.0288 (9)	0.0191 (7)i	0.0380 (9)	−0.0004 (7)i	−0.0023 (8)i	−0.0018 (7)i

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O1i	0.031 (2)i	0.0156 (16)i	0.042 (2)i	−0.0002 (15)i	−0.002 (2)i	−0.0021 (18)i
O2i	0.029 (2)i	0.0209 (16)i	0.055 (2)i	−0.0052 (18)i	0.002 (3)i	−0.0016 (19)i
C1i	0.027 (4)i	0.014 (3)i	0.047 (4)i	0.002 (3)i	0.002 (3)i	0.003 (3)i
C2i	0.041 (5)i	0.037 (3)i	0.064 (5)i	0.006 (3)i	−0.010 (4)i	−0.012 (3)i
C3i	0.042 (5)i	0.041 (4)i	0.076 (5)i	0.008 (3)i	−0.018 (4)i	0.003 (4)i
C4i	0.033 (4)i	0.026 (4)i	0.096 (6)i	0.004 (3)i	0.007 (4)i	0.003 (3)i
C5i	0.044 (5)i	0.041 (4)i	0.064 (5)i	0.006 (3)i	0.015 (4)i	−0.001 (3)i
C6i	0.041 (4)i	0.031 (3)i	0.048 (4)i	0.006 (3)i	0.006 (3)i	0.002 (3)i
C7i	0.036 (4)i	0.025 (3)i	0.034 (3)i	−0.003 (3)i	0.001 (3)i	−0.001 (3)i
C8i	0.061 (5)i	0.041 (4)i	0.048 (4)i	0.005 (4)i	0.013 (4)i	0.003 (3)i
C9	0.076 (6)i	0.065 (5)i	0.053 (5)i	0.001 (5)i	0.030 (4)i	0.001 (4)i
C10i	0.070 (6)i	0.063 (5)i	0.030 (4)i	−0.022 (4)i	0.010 (4)i	0.000 (4)i
C11i	0.086 (7)i	0.052 (4)i	0.040 (4)i	−0.009 (4)i	−0.005 (4)i	0.007 (3)i
C12i	0.053 (5)i	0.036 (3)i	0.035 (4)i	0.003 (3)i	−0.006 (3)i	−0.006 (3)i
C13i	0.027 (4)i	0.017 (2)i	0.034 (3)i	0.005 (2)i	0.004 (3)i	−0.001 (2)i
C14i	0.035 (3)i	0.019 (3)i	0.043 (3)i	−0.001 (2)i	0.006 (3)i	0.003 (2)i
C15i	0.043 (3)i	0.045 (3)i	0.032 (3)i	−0.001 (4)i	0.002 (3)i	0.007 (3)i
C16i	0.045 (5)i	0.045 (4)i	0.037 (4)i	−0.004 (3)i	−0.006 (3)i	0.000 (3)i
C17i	0.044 (4)i	0.031 (3)i	0.041 (4)i	−0.010 (3)i	−0.008 (3)i	0.004 (3)i
C18i	0.036 (4)i	0.031 (3)i	0.031 (3)i	−0.003 (3)i	−0.004 (3)i	0.005 (3)i
C19	0.030 (3)i	0.015 (2)i	0.037 (3)i	0.001 (2)i	−0.010 (4)i	0.001 (3)i
C20i	0.035 (4)i	0.030 (3)i	0.048 (4)i	0.000 (3)i	−0.003 (3)i	−0.008 (3)i
C21i	0.051 (5)i	0.026 (4)i	0.064 (5)i	−0.007 (3)i	−0.012 (4)i	−0.012 (3)i
C22i	0.041 (4)i	0.034 (3)i	0.075 (6)i	−0.014 (3)i	−0.005 (4)i	0.009 (4)i
C23i	0.040 (5)i	0.045 (4)i	0.059 (5)i	−0.013 (3)i	0.005 (4)i	0.002 (4)i
C24i	0.031 (4)i	0.030 (3)i	0.042 (4)i	−0.006 (3)i	0.002 (3)i	−0.006 (3)i

Geometric parameters (Å, °)

Sn1—O1i	2.241 (4)i	C19—C24i	1.383 (9)i
Sn1—C7i	2.132 (5)i	C19—C20i	1.391 (9)i
Sn1—C13i	2.127 (5)i	C20—C21i	1.387 (9)i
Sn1—C19	2.132 (5)i	C21—C22i	1.358 (10)i
Sn1—O2i	2.237 (3)i	C22—C23i	1.377 (10)i
P1—O1i	1.514 (4)i	C23—C24i	1.383 (9)i
P1—O2i	1.501 (4)i	C2—H2i	0.9500i
P1—C1i	1.801 (6)i	C3—H3i	0.9500i
P1—H1i	1.33 (5)i	C4—H4i	0.9500i
C1—C2i	1.382 (10)i	C5—H5i	0.9500i
C1—C6i	1.381 (10)i	C6—H6i	0.9500i
C2—C3i	1.391 (10)i	C8—H8i	0.9500i
C3—C4i	1.380 (10)i	C9—H9	0.9500i
C4—C5i	1.368 (11)i	C10—H10i	0.9500i
C5—C6i	1.390 (10)i	C11—H11i	0.9500i
C7—C12i	1.398 (8)i	C12—H12i	0.9500i
C7—C8i	1.382 (9)i	C14—H14i	0.9500i
C8—C9	1.380 (11)i	C15—H15i	0.9500i
C9—C10i	1.357 (11)i	C16—H16i	0.9500i
C10—C11i	1.376 (11)i	C17—H17i	0.9500i

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C11—C12i	1.382 (10)i	C18—H18i	0.9500i
C13—C14i	1.398 (7)i	C20—H20i	0.9500i
C13—C18i	1.410 (8)i	C21—H21i	0.9500i
C14—C15i	1.380 (8)i	C22—H22i	0.9500i
C15—C16i	1.398 (9)i	C23—H23i	0.9500i
C16—C17i	1.379 (9)i	C24—H24i	0.9500i
C17—C18i	1.368 (8)i		
O1—Sn1—C7i	93.41 (19)	C19—C20—C21i	119.3 (7)i
O1—Sn1—C13i	90.22 (17)i	C20—C21—C22i	121.0 (6)i
O1—Sn1—C19	89.73 (17)i	C21—C22—C23i	120.6 (6)i
O1—Sn1—O2i	175.99 (15)i	C22—C23—C24i	119.0 (6)i
C7—Sn1—C13i	124.1 (2)i	C19—C24—C23i	121.1 (6)i
C7—Sn1—C19	119.4 (3)i	C1—C2—H2i	120.00i
O2i—Sn1—C7i	90.41 (19)	C3—C2—H2i	120.00i
C13—Sn1—C19	116.4 (3)i	C2—C3—H3i	120.00i
O2i—Sn1—C13i	88.66 (17)i	C4—C3—H3i	120.00i
O2i—Sn1—C19	87.32 (17)i	C3—C4—H4i	120.00i
O1—P1—O2i	114.4 (2)i	C5—C4—H4i	120.00i
O1—P1—C1i	108.6 (3)i	C4—C5—H5i	120.00i
O2—P1—C1i	110.7 (2)i	C6—C5—H5i	120.00i
O1—P1—H1i	110 (2)i	C1—C6—H6i	120.00i
O2—P1—H1i	110 (2)i	C5—C6—H6i	120.00i
C1—P1—H1i	103 (2)i	C7—C8—H8i	119.00i
Sn1—O1—P1i	132.9 (3)i	C9—C8—H8i	120.00i
Sn1i—O2—P1i	145.1 (2)i	C8—C9—H9	120.00i
P1—C1—C2i	121.8 (5)i	C10—C9—H9	119.00i
C2—C1—C6i	119.6 (6)i	C9—C10—H10i	120.00i
P1—C1—C6i	118.6 (5)i	C11—C10—H10i	120.00i
C1—C2—C3i	119.8 (7)i	C10—C11—H11i	120.00i
C2—C3—C4i	120.0 (7)i	C12—C11—H11i	120.00i
C3—C4—C5i	120.4 (6)i	C7—C12—H12i	120.00i
C4—C5—C6i	119.7 (7)i	C11—C12—H12i	120.00i
C1—C6—C5i	120.5 (7)i	C13—C14—H14i	119.00i
Sn1—C7—C8i	121.7 (5)i	C15—C14—H14i	120.00i
Sn1—C7—C12i	120.5 (4)i	C14—C15—H15i	120.00i
C8—C7—C12i	117.8 (5)i	C16—C15—H15i	120.00i
C7—C8—C9	121.0 (7)i	C15—C16—H16i	121.00i
C8—C9—C10i	120.9 (7)i	C17—C16—H16i	121.00i
C9—C10—C11i	119.4 (7)i	C16—C17—H17i	119.00i
C10—C11—C12i	120.6 (7)i	C18—C17—H17i	119.00i
C7—C12—C11i	120.3 (6)i	C13—C18—H18i	120.00i
Sn1—C13—C14i	120.7 (4)i	C17—C18—H18i	120.00i
C14—C13—C18i	117.6 (5)i	C19—C20—H20i	120.00i
Sn1—C13—C18i	121.7 (4)i	C21—C20—H20i	120.00i
C13—C14—C15i	121.2 (5)i	C20—C21—H21i	119.00i
C14—C15—C16i	120.2 (6)i	C22—C21—H21i	120.00i
C15—C16—C17i	118.8 (6)i	C21—C22—H22i	120.00i
C16—C17—C18i	121.4 (6)i	C23—C22—H22i	120.00i

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C13—C18—C17i	120.7 (5)i	C22—C23—H23i	121.00i
Sn1—C19—C20i	120.8 (5)i	C24—C23—H23i	120.00i
Sn1—C19—C24i	120.2 (4)i	C19—C24—H24i	119.00i
C20—C19—C24i	119.0 (5)i	C23—C24—H24i	119.00i
C7—Sn1—O1—P1i	−89.4 (4)i	O1—P1—C1—C6i	134.2 (5)i
C13—Sn1—O1—P1i	34.8 (4)i	O2—P1—C1—C2i	78.1 (5)i
C19—Sn1—O1—P1i	151.2 (4)i	O2—P1—C1—C6i	−99.4 (5)i
O1—Sn1—C7—C8i	172.5 (5)i	P1—C1—C2—C3i	−178.7 (5)i
O1—Sn1—C7—C12i	−7.0 (5)i	C6—C1—C2—C3i	−1.2 (9)i
C13—Sn1—C7—C8i	79.9 (6)i	P1—C1—C6—C5i	179.9 (5)i
C13—Sn1—C7—C12i	−99.6 (5)i	C2—C1—C6—C5i	2.3 (9)i
C19—Sn1—C7—C8i	−95.9 (5)i	C1—C2—C3—C4i	−1.4 (10)i
C19—Sn1—C7—C12i	84.6 (5)i	C2—C3—C4—C5i	2.8 (10)i
O2i—Sn1—C7—C8i	−8.7 (5)i	C3—C4—C5—C6i	−1.7 (10)i
O2i—Sn1—C7—C12i	171.8 (5)i	C4—C5—C6—C1i	−0.9 (10)i
O1—Sn1—C13—C14i	107.3 (5)i	Sn1—C7—C8—C9	−178.9 (6)i
O1—Sn1—C13—C18i	−74.6 (4)i	C12—C7—C8—C9	0.6 (10)i
C7—Sn1—C13—C14i	−158.4 (4)i	Sn1—C7—C12—C11i	179.1 (5)i
C7—Sn1—C13—C18i	19.7 (5)i	C8—C7—C12—C11i	−0.5 (9)i
C19—Sn1—C13—C14i	17.5 (5)i	C7—C8—C9—C10i	−0.7 (12)i
C19—Sn1—C13—C18i	−164.4 (4)i	C8—C9—C10—C11i	0.5 (12)i
O2i—Sn1—C13—C14i	−68.9 (5)i	C9—C10—C11—C12i	−0.3 (12)i
O2i—Sn1—C13—C18i	109.3 (4)i	C10—C11—C12—C7i	0.3 (11)i
O1—Sn1—C19—C20i	132.0 (5)i	Sn1—C13—C14—C15i	177.6 (5)i
O1—Sn1—C19—C24i	−49.1 (5)i	C18—C13—C14—C15i	−0.6 (9)i
C7—Sn1—C19—C20i	38.2 (6)i	Sn1—C13—C18—C17i	−177.7 (5)i
C7—Sn1—C19—C24i	−142.8 (5)i	C14—C13—C18—C17i	0.5 (8)i
C13—Sn1—C19—C20i	−137.9 (5)i	C13—C14—C15—C16i	−0.2 (10)i
C13—Sn1—C19—C24i	41.0 (5)i	C14—C15—C16—C17i	1.1 (10)i
O2i—Sn1—C19—C20i	−50.8 (5)i	C15—C16—C17—C18i	−1.3 (10)i
O2i—Sn1—C19—C24i	128.2 (5)i	C16—C17—C18—C13i	0.5 (9)i
C7—Sn1—O2i—P1i	117.5 (5)i	Sn1—C19—C20—C21i	177.3 (5)i
C13—Sn1—O2i—P1i	−6.6 (4)i	C24—C19—C20—C21i	−1.7 (10)i
C19—Sn1—O2i—P1i	−123.2 (5)i	Sn1—C19—C24—C23i	−177.4 (5)i
O2—P1—O1—Sn1i	63.4 (4)i	C20—C19—C24—C23i	1.6 (9)i
C1—P1—O1—Sn1i	−172.4 (4)i	C19—C20—C21—C22i	1.0 (10)i
O1—P1—O2—Sn1i	−174.3 (4)i	C20—C21—C22—C23i	−0.2 (11)i
C1—P1—O2—Sn1i	62.6 (5)i	C21—C22—C23—C24i	0.1 (11)i
O1—P1—C1—C2i	−48.3 (6)i	C22—C23—C24—C19	−0.8 (10)i

Symmetry codes: (i) −*x*−1/2, *y*−1/2, *z*; (i) −*x*−1/2, *y*+1/2, *z*.i

Hydrogen-bond geometry (Å, °)

D—H···*A*	*D*—Hi	H···*A*	*D*···*A*	*D*—H···*A*
C9—H9···Cg1i	0.95i	2.79	3.656 (9)	151i
C18—H18···Cg1i	0.95i	2.91i	3.714 (6)i	143i

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Symmetry codes: (i) x+1/2, y, −z+1/2; (i) −x−1/2, y+1/2, z.i

Fig. 1

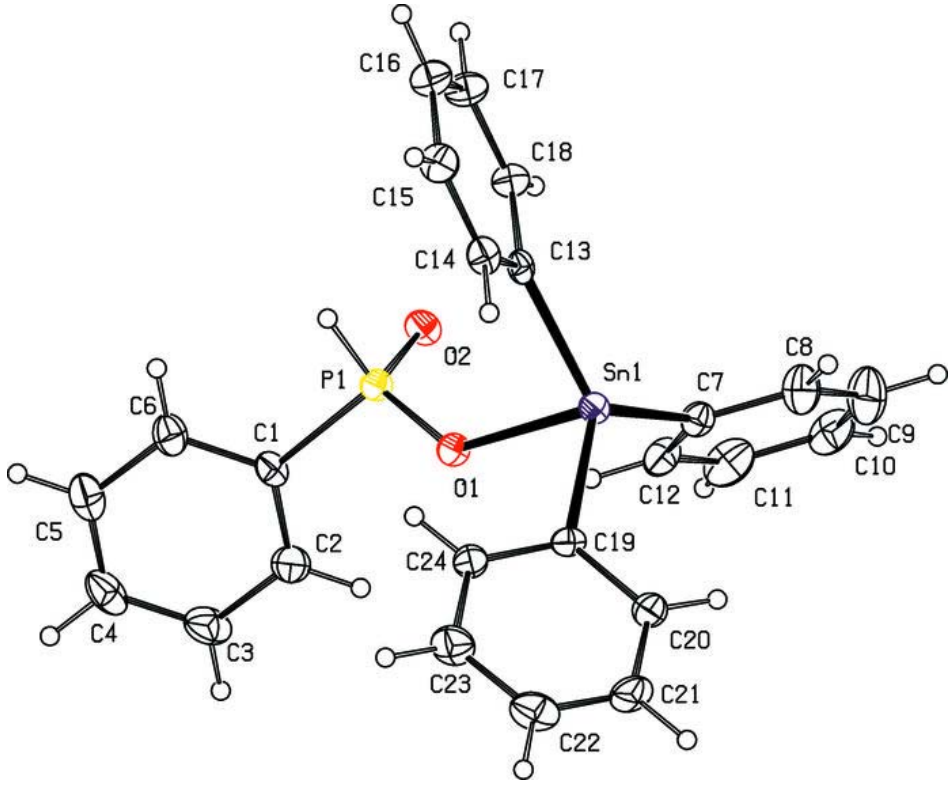

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Fig. 2m

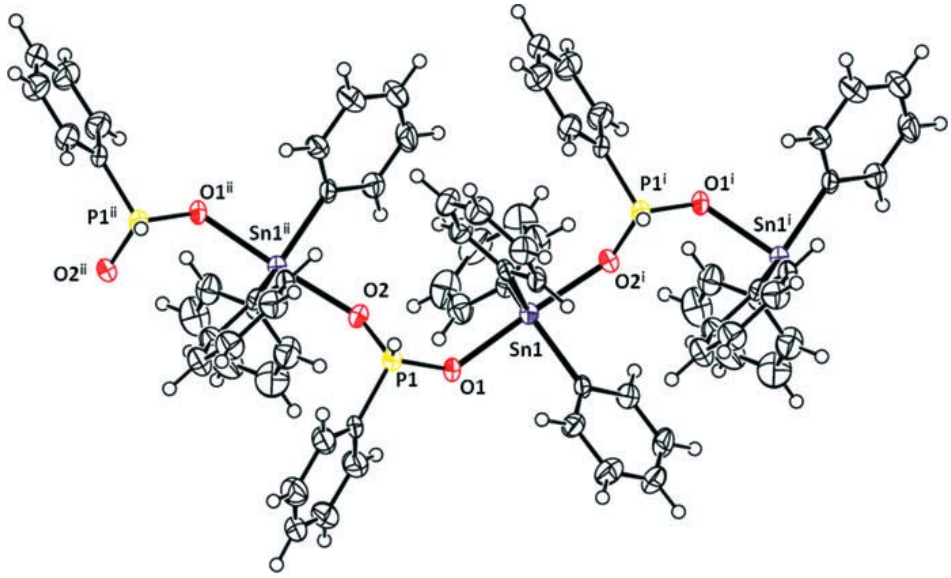

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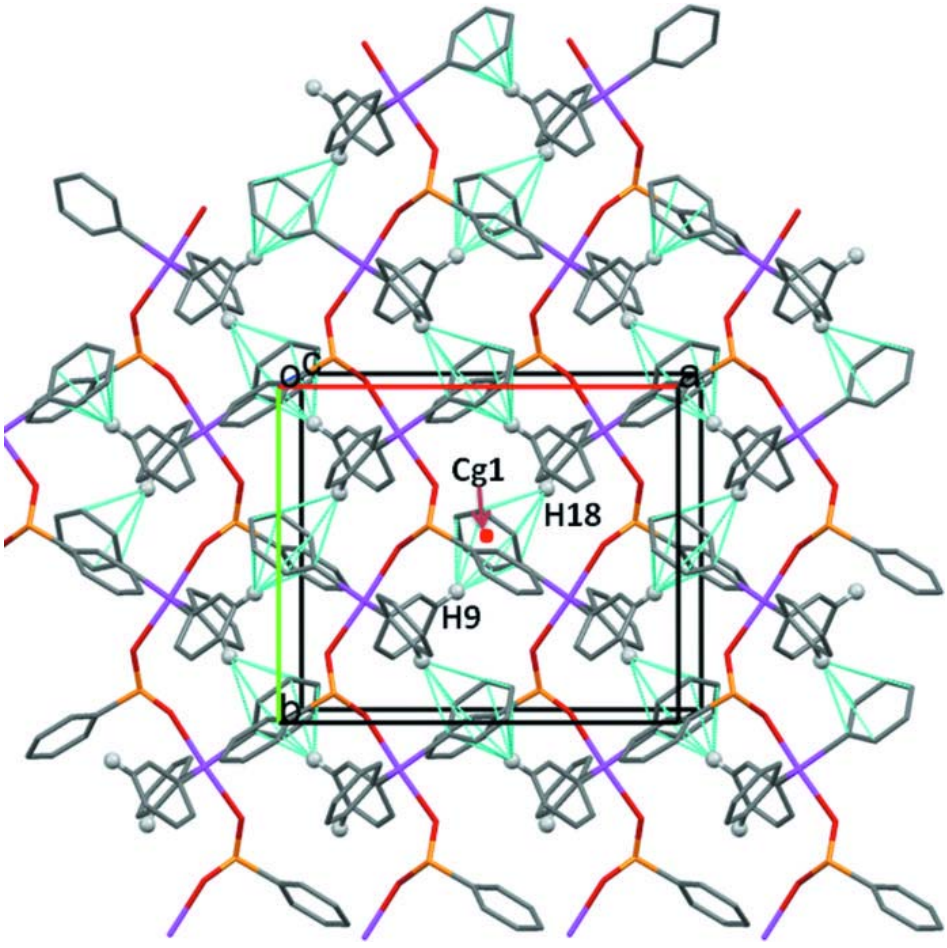
Fig. 3m



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